Hydrogeology and hydrochemistry of the Hosaina and Dila area

Jiri Sima

Contents

- Introduction
- Principles
- Legend to hydrogeological maps
- Legend to hydrochemical maps
- Explanatory notes and database
- Specific aspects
- Groundwater resources

Introduction

1 : 250 000 a map from national series

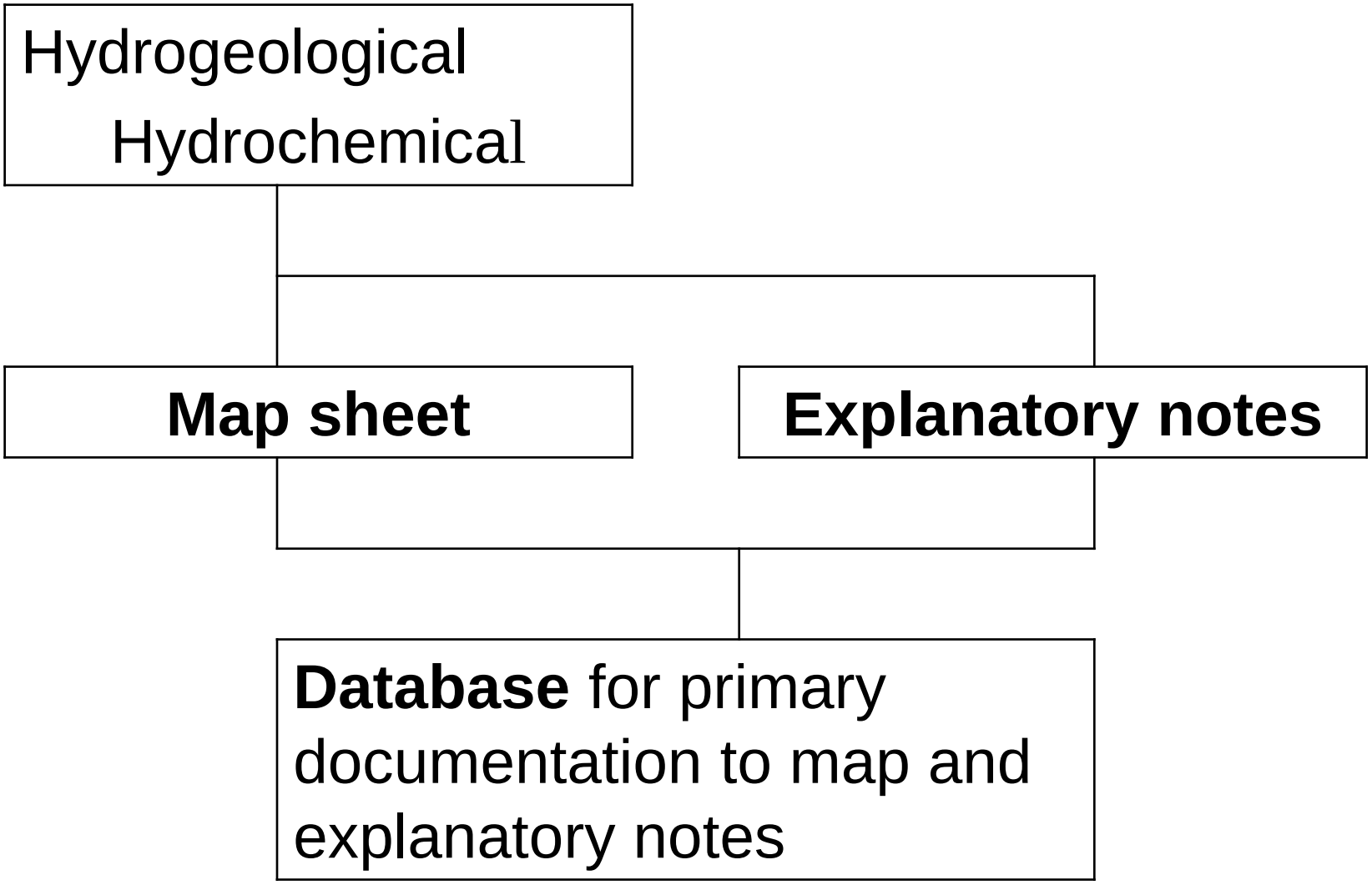
1 : 50 000 starting point for new mapping of important areas (Angecha, Hawasa, Shashemene)

Arjo	**Akaki Beseka**	**Nazret**
Jima	**Hosaina**	**Asela**
Dime	**Dila**	**Dodola**
	Agere Mariam	**Negele**

Principle - Aim of maps

- Groundwater and rocks – qualitative – permeability and quantitative potential of rock units – aquifers / aquitards / aquiclides
- Groundwater chemistry and quality
- Water points (spatial distribution and type)
- Supporting information (surface water network and divide, gw flow direction, river discharge, etc.)

Integral parts of maps



General legend to map

- extent of aquifers and their types, and lithology with tectonic features
- basic structural and topographical settings
- all-important hydrogeological features (natural, man made)
- water chemistry and quality, thermal water, and mineral water provinces

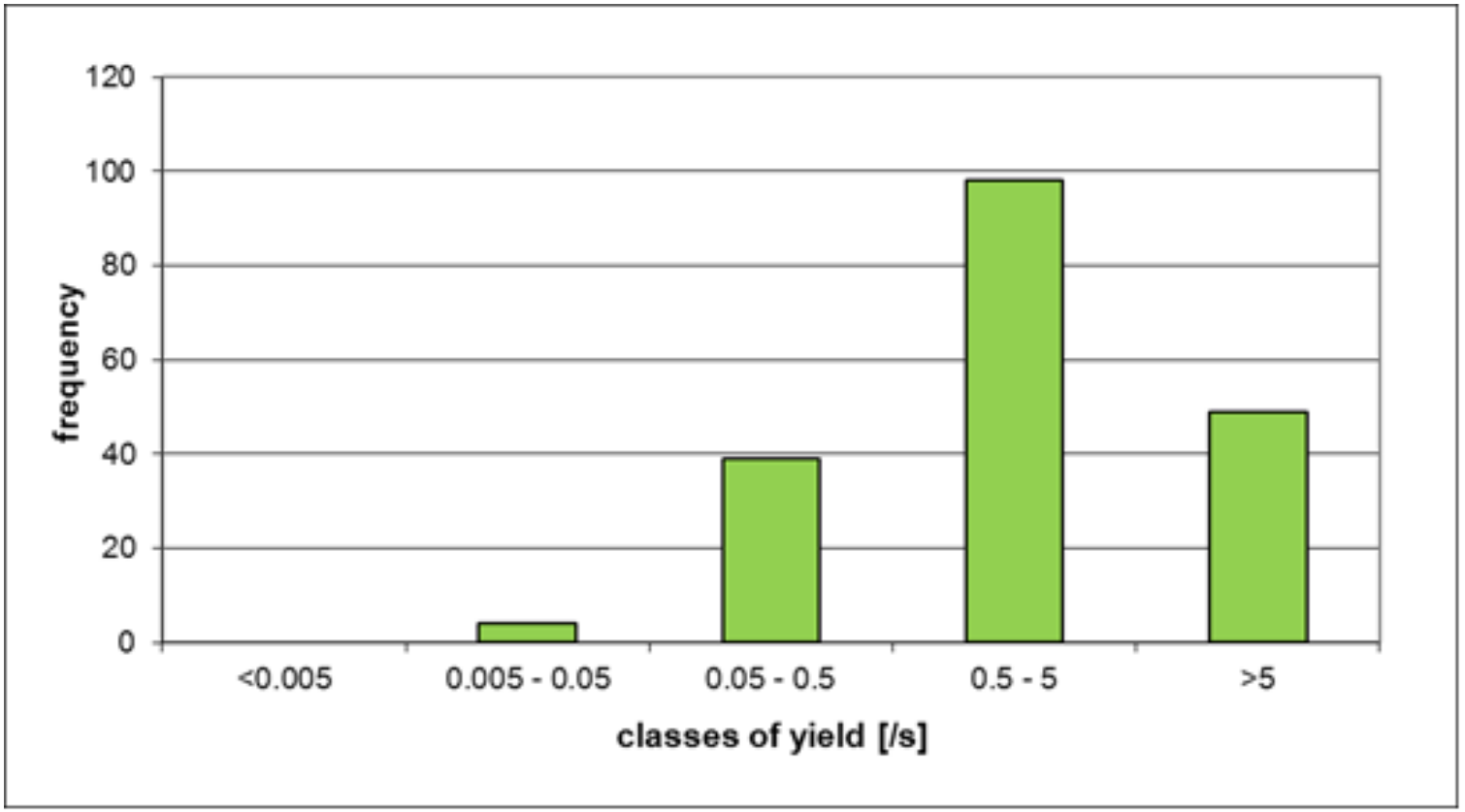
Type of permeability

Aquifer	Color	Rock example
Porous	Blue	Alluvial
Fissured	Green	Sandstone/basalt
Fissured/karstic	Green (dark)	Limestone
Basement	Brown-red	Granite/gneiss
Aquiclude	Brown	Marlstone
Aquitard	Brown (dark)	Claystone
Mixed	Blue/green strips	Volcanic/sedimentary

Quantification of permeability

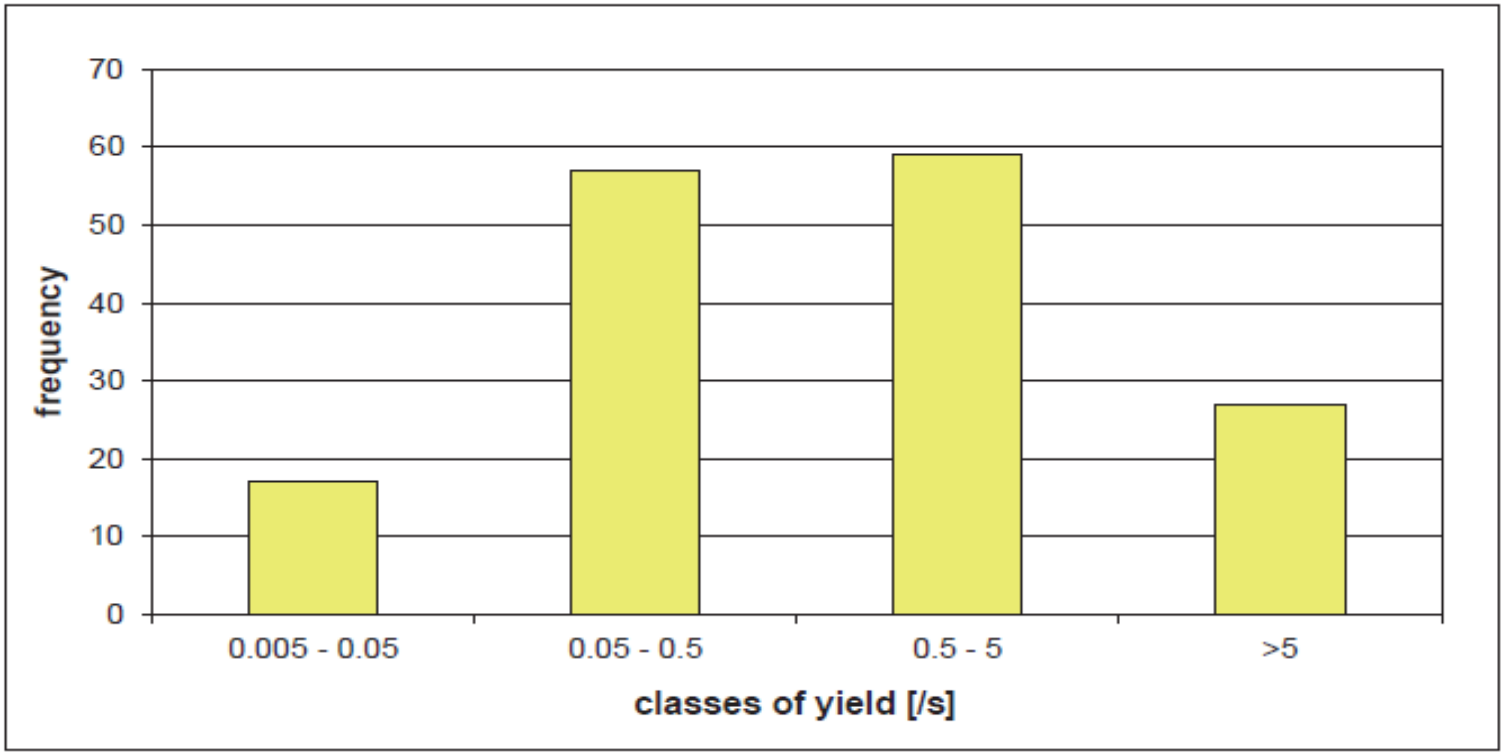
Aquifer class	T (m^2/d)	q (l/sm)	Yield (l/s)
Extra high	500	5	More 25
High	100	1	5.1-25
Moderate	1.11-10	0.011-0.1	0.51-5
Low	0.11 - 1	0.01	0.051-0.5
Extra low	0.1	0.001	0.005-0.05
Neglegible /seepage			Less 0.005

Quantification volcanic, Hosaina



Number of data	Max	Min	Median	Average
190	70	0.035	3	4.67

Quantification volcanic, Dila



Number of data	Max	Min	Median	Average
344	100	0.011	0.683	3.6

Groundwater and rocks 1

Intergranular permeability - blue

- Extensive and moderately productive or local highly productive aquifers (T = 1.1–10 m^2/d, q = 0.011–0.1 l/s.m, with spring and well yield Q = 0.51–5 l/s) (light blue)

Quaternary alluvial and eluvial sediments and polygenetic infill of depresions, volcano-sedimentary rocks

Groundwater and rocks 2

Fissured aquifers - green

- Extensive and moderately productive or local highly productive aquifers (T = 1.1–10 m^2/d, q = 0.011–0.1 l/s.m, with spring and well yield Q = 0.51–5 l/s) (light green)

Basalt of rift floor, ignimbrite, rhyolite and trachyte of escrpment and highlands

Groundwater and rocks 3

Extensive and low productive aquifers develeoped in basement rocks with local and limited groundwater resources (T = 0.11–1 m^2/d, q = 0.0011–0.01 l/s.m, with spring and well yield Q = 0.051–0.5 l/s). (brown-red)

Metamorphic rocks and granite

Groundwater and rocks 4

Rocks with fissured porosity and with essentially no groundwater resources - brown

- Aquiclude – rock unit with limited groundwater resources - light brown for $T = 1 m^2/d$, $q = 0.01$ l/sm, $Q = 0.05 – 0.5$ l/s
- Aquitard – rock unit with essentially no groundwater resources - dark brown for $T = 0.1 m^2/d$, $q = 0.001$ l/sm, $Q = 0.05$

Obsidian and pitch stone

Groundwater and rocks 5
Mixed aquifers

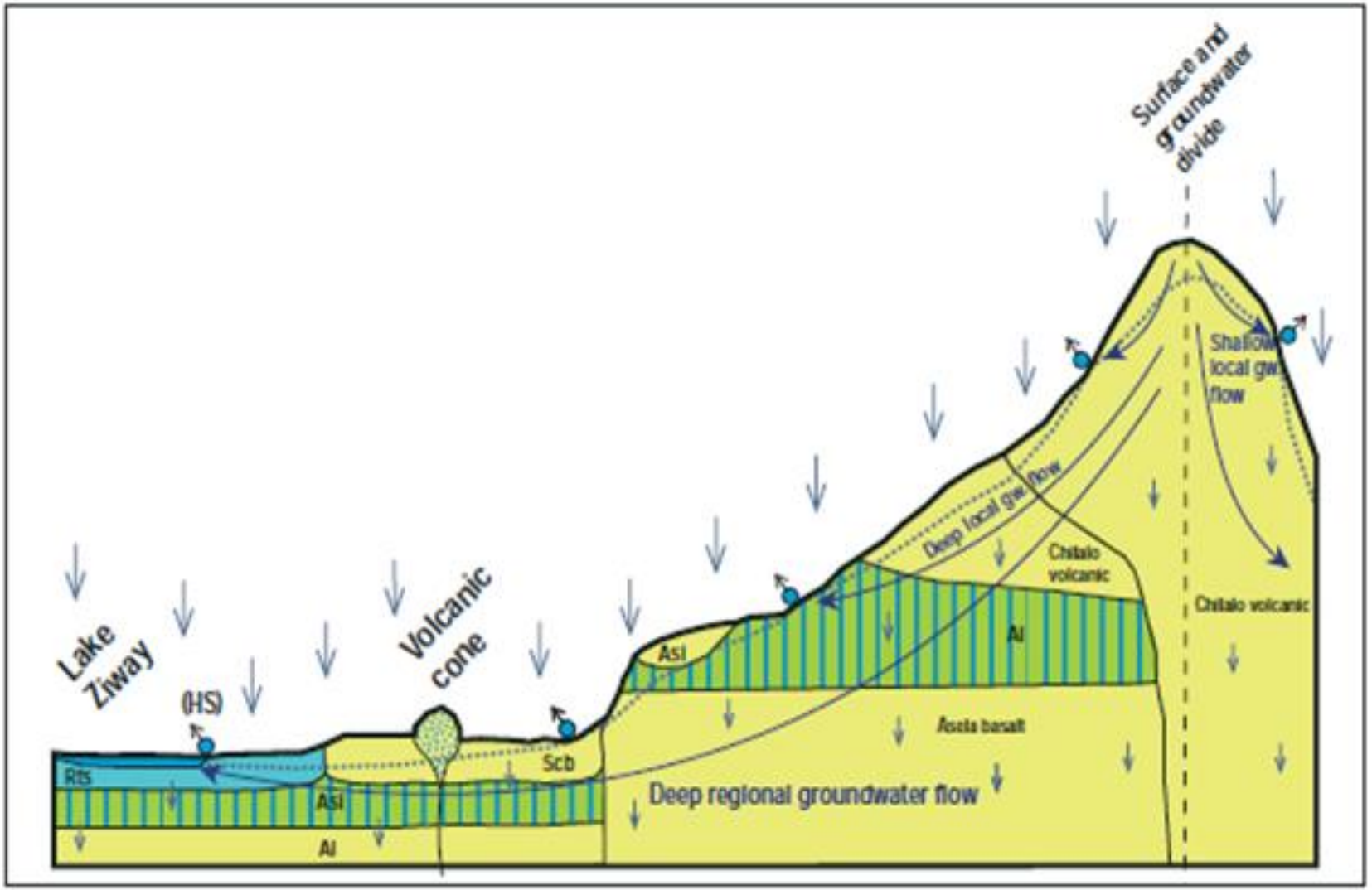
Volcanic rocks are often mixed with

- **sediments accumulated in between individual lava flows or volcanic episodes by rivers and lakes**
- **relatively thick layers of unwelded tuffs, ash flows and pumiceous pyroclastic material.**

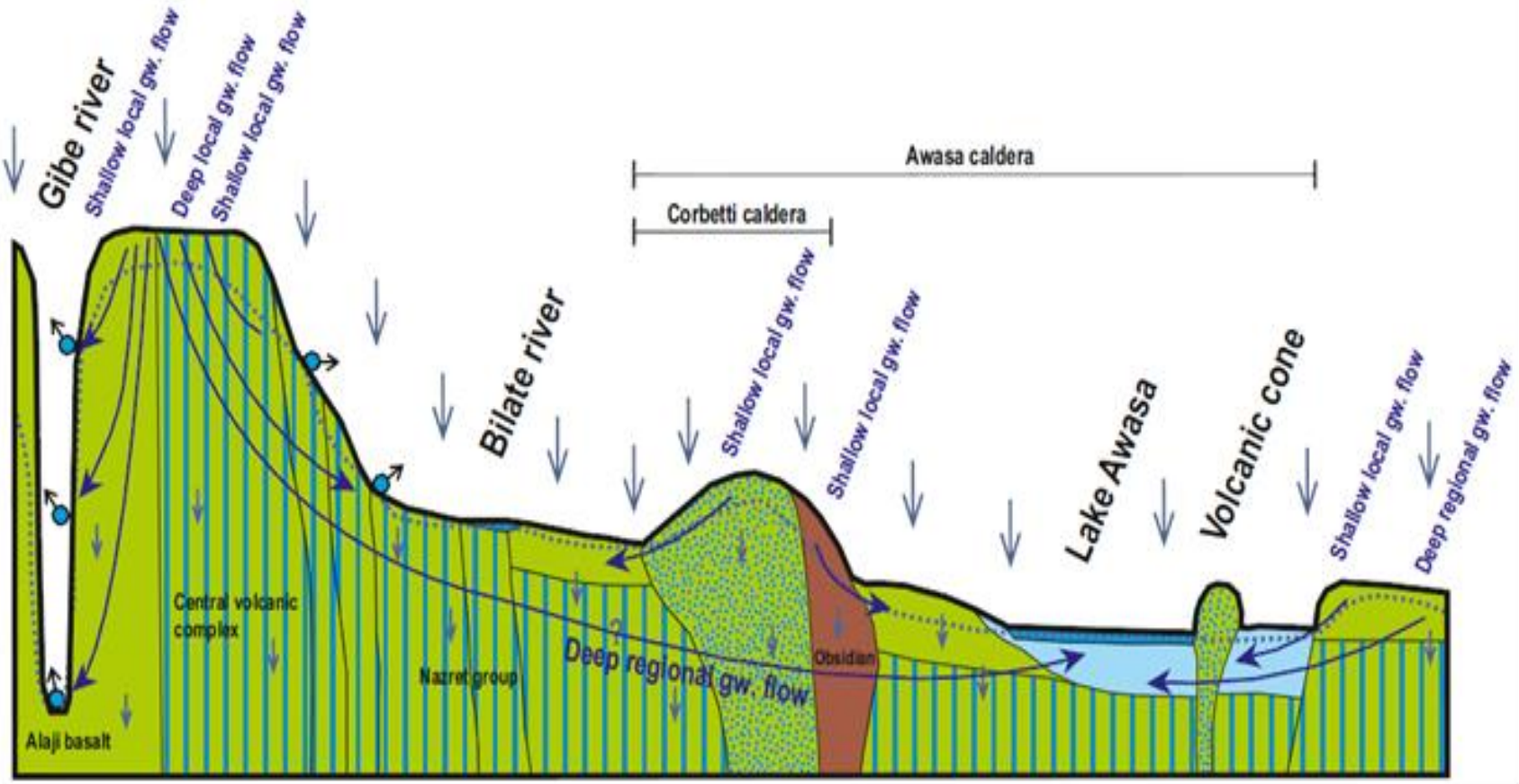
These intercalated porous materials do not act as independent aquifers but they form a mixed fissured and porous multilayered aquifers – expressed by relevant green and blue horizontal strips

Ignimbrites, rhyolite, trachyte lava flows mixed (intercalated) with tuffs, pumice, river and lake sediments

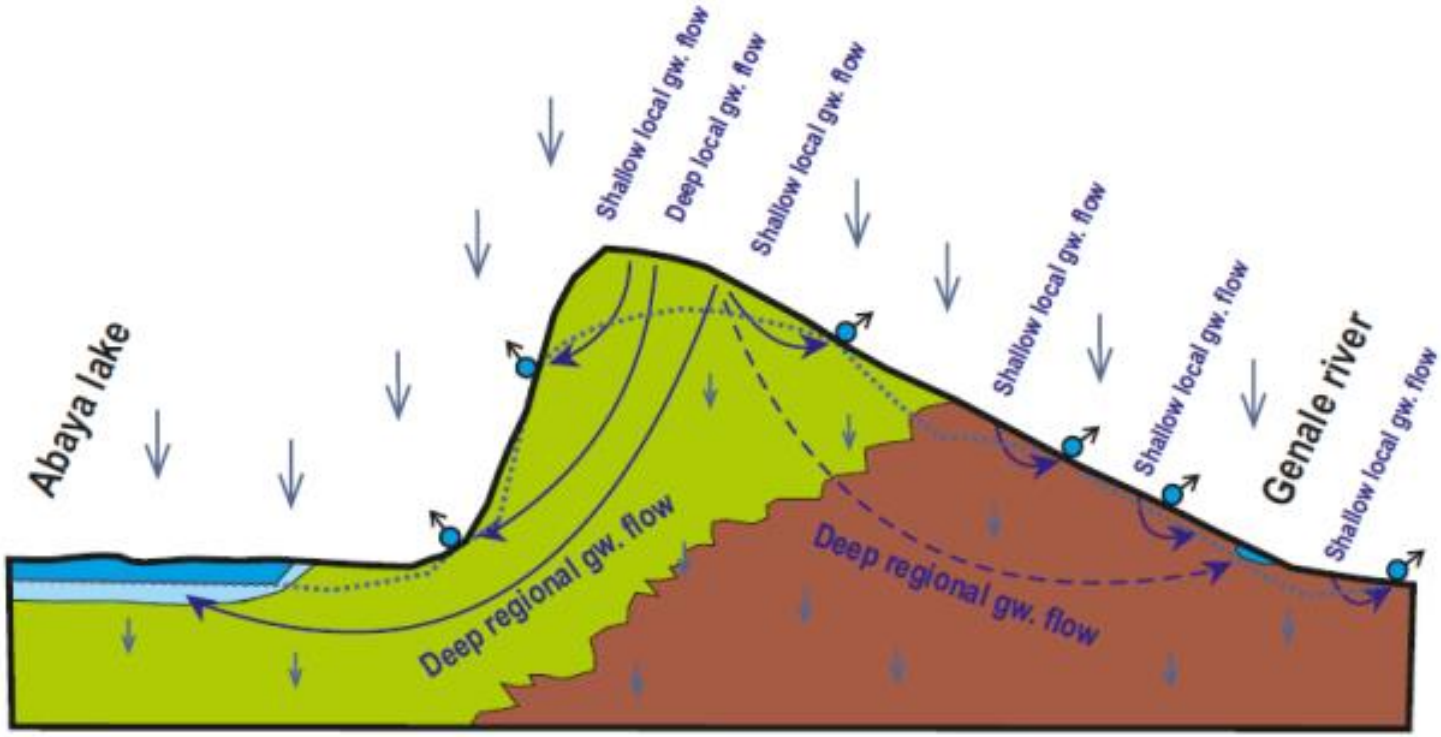
Hydrogeological scheme Hosaina E



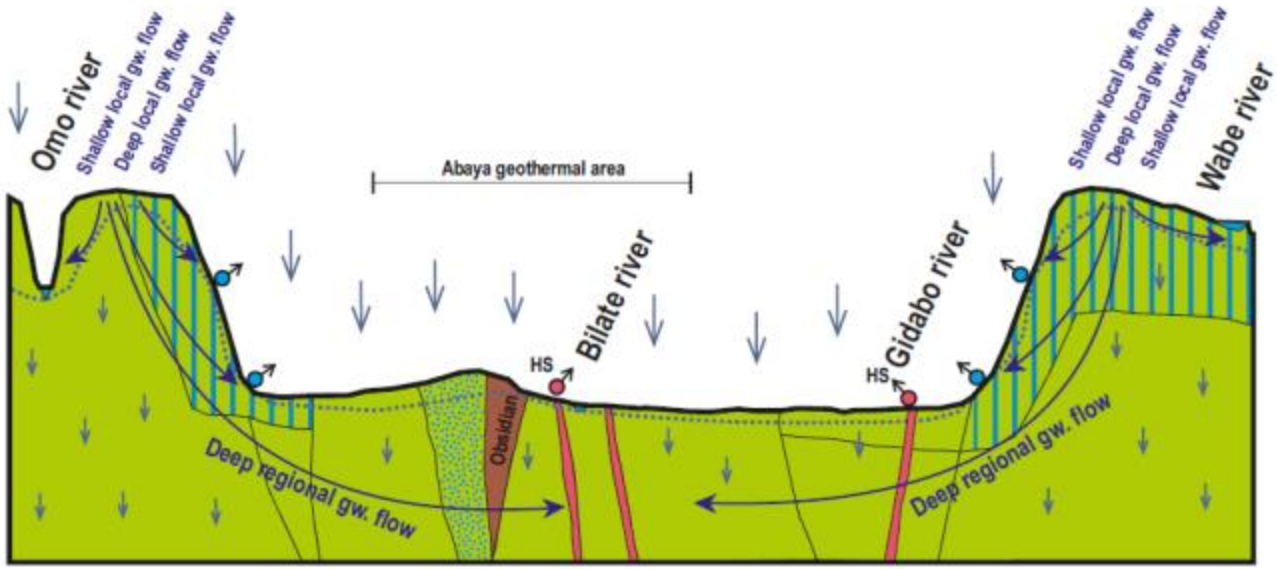
Hydrogeological scheme Hosaina W



Hydrogeological scheme Genale River



Hydrogeological scheme Bilate River



Map.pdf

Hydrochemical types

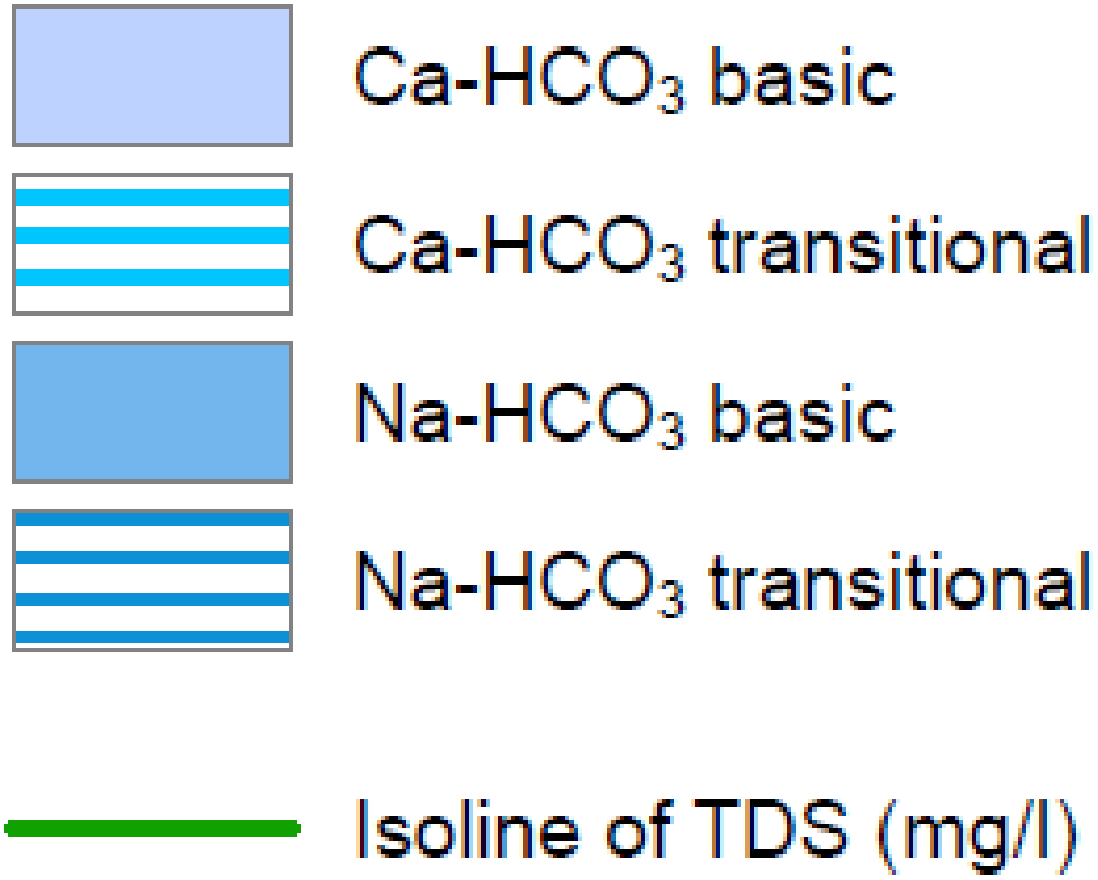
There are three hydrochemical types defined based on the concentration of individual dissolved solids:

- **Basic – higher than 50Meq%**
- **Transitional between 35 and 50 Meq%**
- **Mixed – only one ion over 35 Meq%**

Hydrochemical types

No.	Color	Hydrochemical type of groundwater
1	light blue	$Ca\text{-}HCO_3$
2	violet	$Mg\text{-}HCO_3$
3	dark blue	$Na\text{-}HCO_3$
4	yellow	$Ca\text{-}SO_4$
5	brown	$Mg\text{-}SO_4$
6	red	$Na\text{-}SO_4$
7	green	Na-Cl
8	Dark green	Ca-Cl

Hydrochemical map - legend



Drinking water standards

NO_3 Water point (well) with high concentration of NO_3

Area with groundwater with high TDS
and high content of F

- Map.pdf

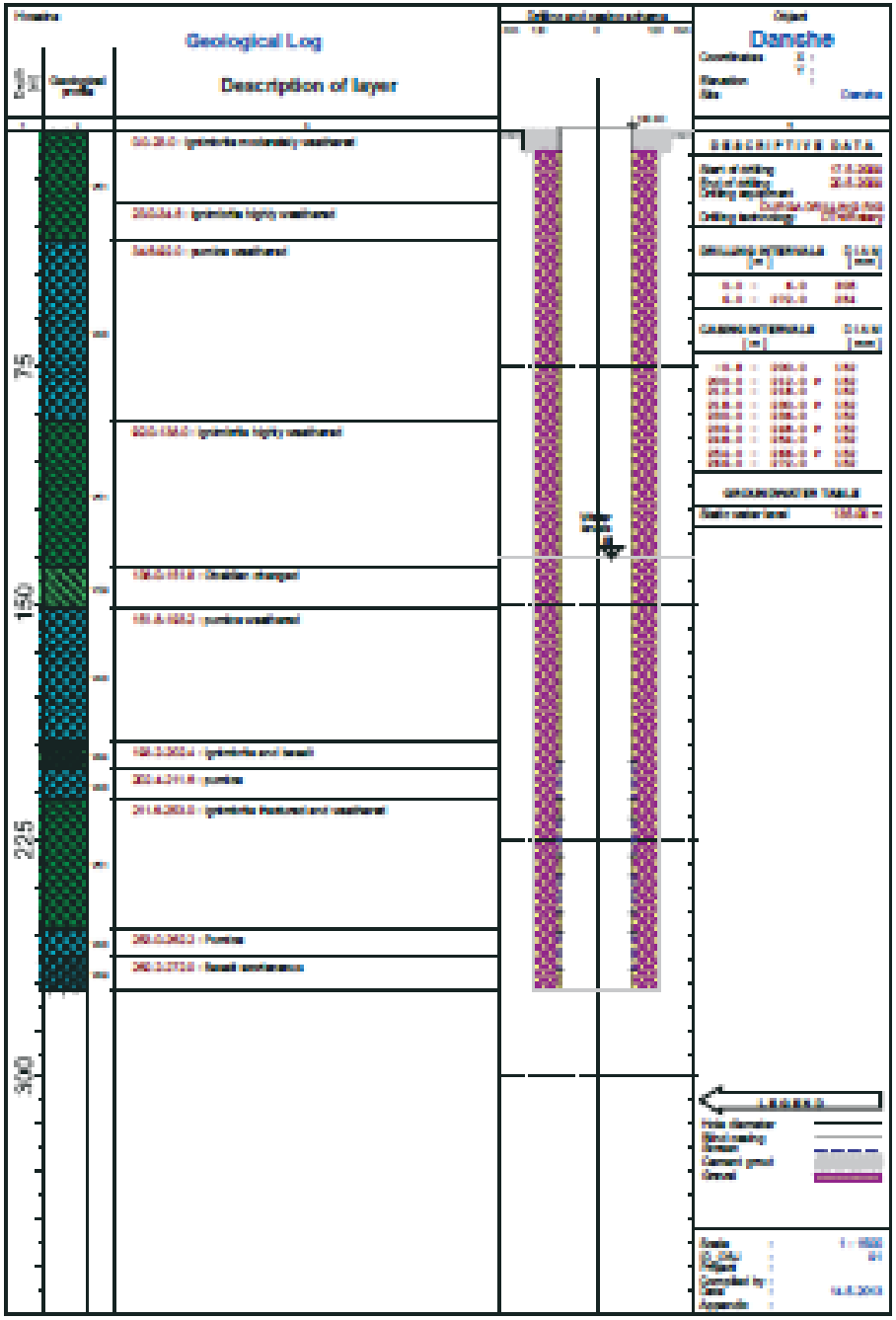
Content of explanatory note

1. Basic characteristic of the area
2. Selected physical and geographical settings
3. Geological settings
4. Hydrogeological settings (aquifer system definition)
5. Hydrochemistry (of natural waters)
6. Natural resources of the area

Annexes (WP inventory, chemical analyses, well logs)

Annexes – database output

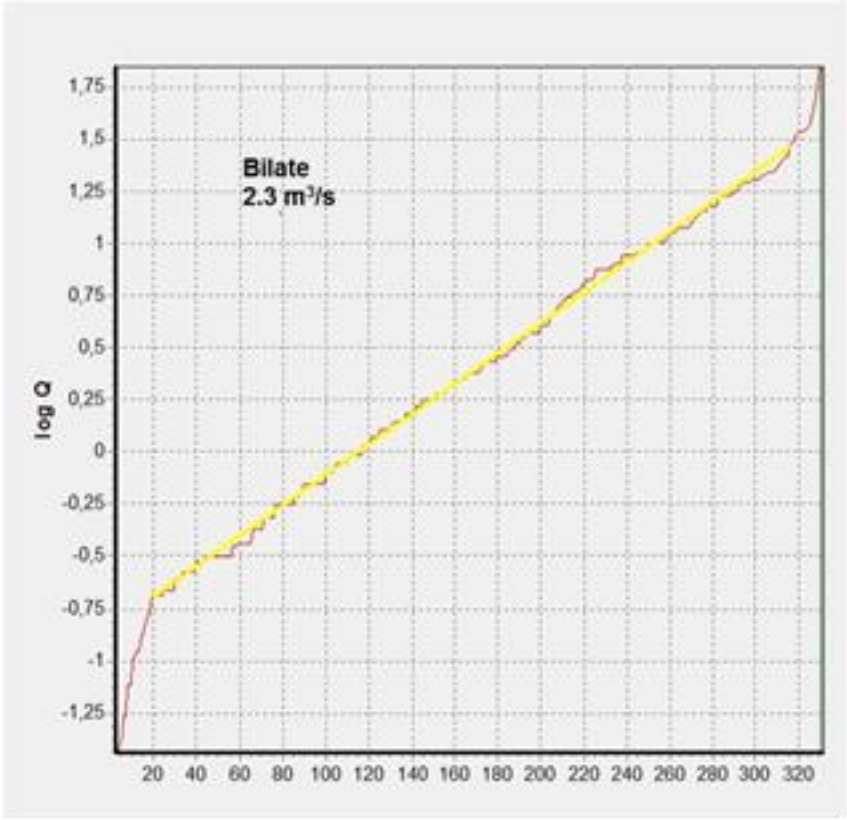
- Water point inventory (bore holes, dug wells, springs, water holes, rivers)
- Chemistry (results of chemical analysis - used for compilation of hydrochemical map and assessment of water quality)
- Well logs (essence of drilling reports – information for next drilling) - same color and ornaments used in map for geology

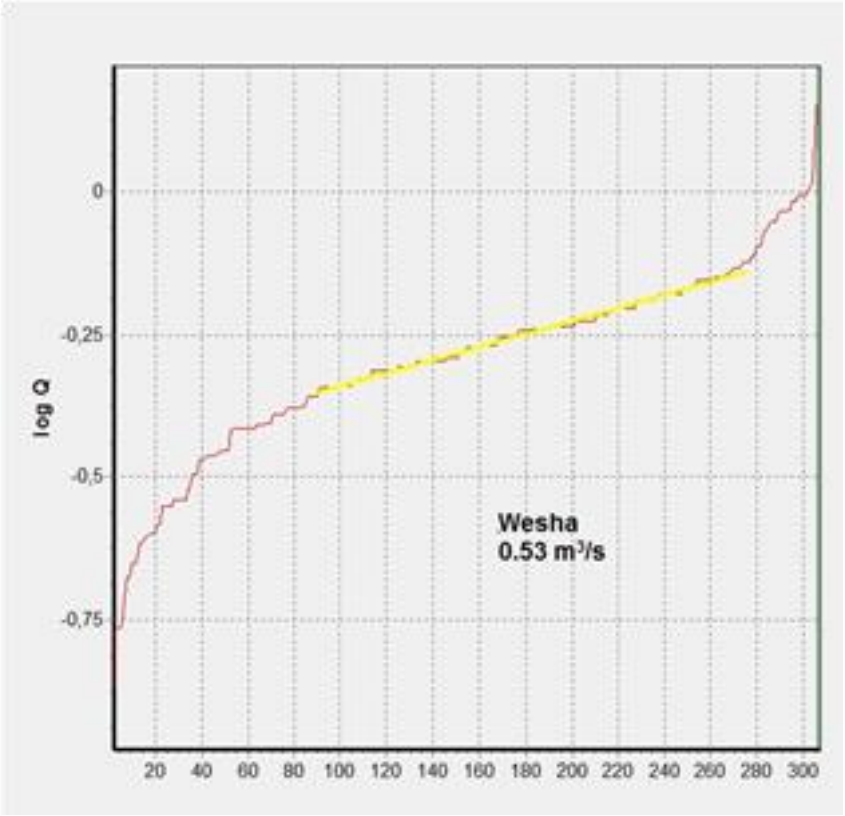

Geological Log
Description of layer
Depth [m]
Geological profile
Drilling and casing scheme
Object
Danche
Coordinates
Elevation
Site
Danche
DESCRIPTIVE DATA
Start of drilling
End of drilling
Drilling equipment
Drilling technology
DRILLING INTERVALS
[m]
Ø [mm]
CASING INTERVALS
[m]
Ø [mm]
GROUNDWATER TABLE
Static water level
LEGEND
Hole diameter
Blind casing
Screen
Cement grout
Gravel
Scale
1 : 1000
Sh. (No.)
Object
Completed by
Date
Appendix
75
150
225
300

Well log

GWR - Baseflow – Kille method

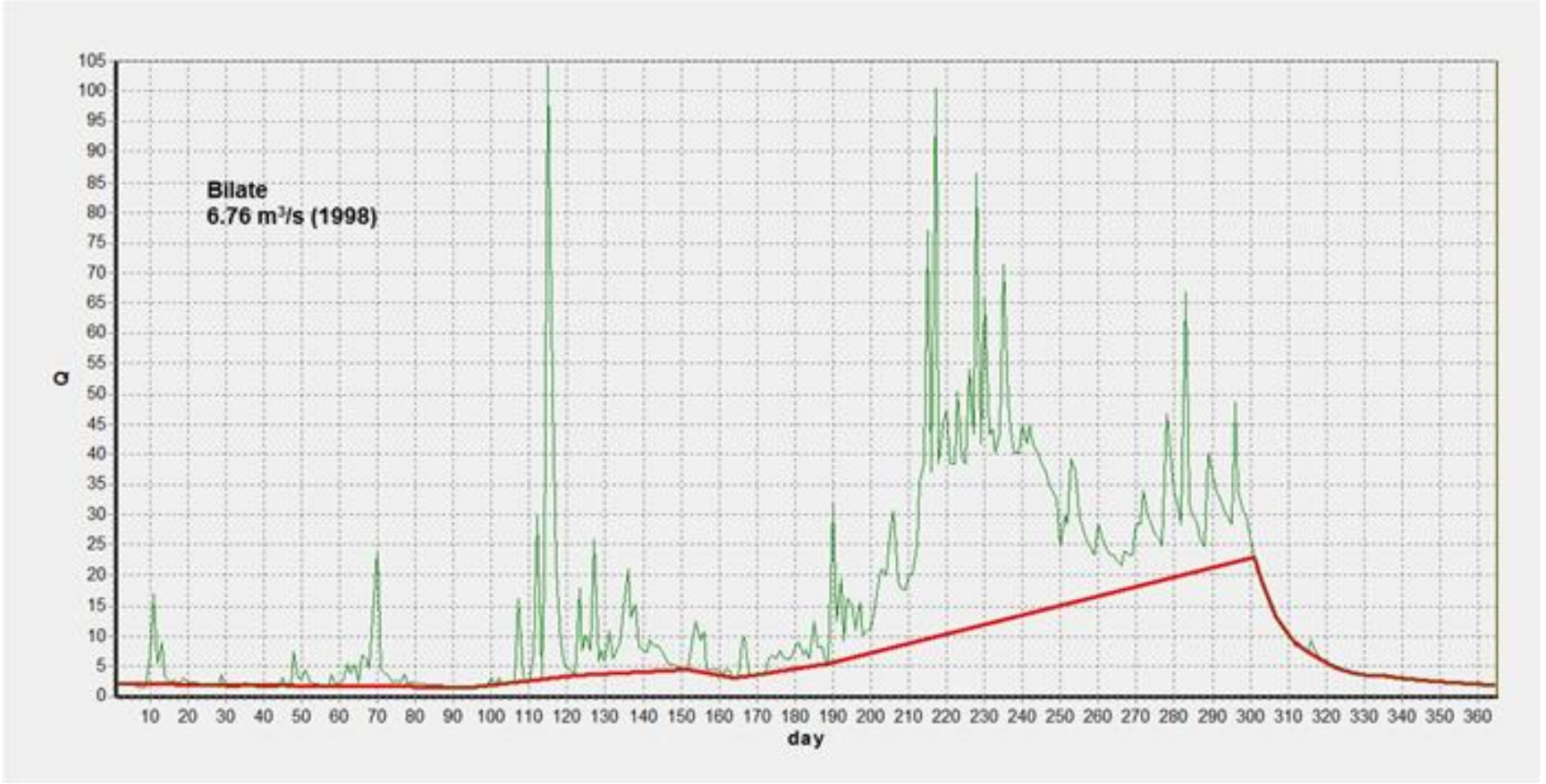
daily minimum in each month – provide average of baseflow for whole measurement period (2,15)





Baseflow – hydrograph separation

baseflow for given year



Baseflow characteristics - Hosaina

Map ID	River	Area [km^2]	Specific runoff [l/s.km^2]	Kille method [m^3/s]	Hydrograph separation [m^3/s]	Specific baseflow [l/s.km^2]	Aquifer
1	Batena	71	16.9	0.28	0.49	3.9/6.9	Volcanic/esc
2	Bilate	2,009	5.5	2.30	6.76	1.1/3.4	Volcanic/floor
3	Dedaba	163	6.4	0.15	0.80	0.9/4.9	Volcanic/esc
4	Djidu	1,794	3.2	0.24	1.29	0.1/0.7	Volcanic/floor
6	Gedemso	52	46.3	0.32	1.08	6.2/20.8	Volcanic/esc
13	Weira	522	14.0	1.03	3.42	2.0/6.6	Volcanic/esc
15	Wesha	40	15.8	0.53	0.61	13.3/15.3	Volcanic/esc
17	Ajancho	306	3.8	0.25	0.76	0.8/2.5	Volcanic/plat
18	Shopa	19	76.3	0.31	0.57	16.3/30.0	Volcanic/plat
19	Weibo	2,368.4	0.73	0.32	0.74	0.1/0.3	Volcanic/plat
20	Sana	2,190	1.6	1.04	1.81	0.5/0.8	Volcanic/plat
24	Tikur Woha	625	5.8		0.96	1.54	Lacustrine/floor

Groundwater resources

	Input	Area [km^2]	Resources total	Remark
Precipitation	1,137 mm 1,100 mm	17,281 18,335	19,649 Mm^3/year 20,169 Mm^3/year	
Total water resources – map	6.8 l/s.km^2 9.0 l/s.km^2	17,281 18,335	3,708 Mm^3/year 5,207 Mm^3/year	19 % rainfall 25 % rainfall
Renewable groundwater resources active aquifers	1.6 l/s.km^2 3.8 l/s.km^2	17,085 17,222	863 Mm^3/year 2,065 Mm^3/year	4 % rainfall 10 % rainfall
Static groundwater resources of fissured and mixed aquifers	5 % porosity 100 m thickness	15,184 16,476	75,920 Mm^3 82,380 Mm^3	Not proved
Static groundwater resources porous aquifers	15% 100 m thickness	1,903 746	28,545 Mm^3 11,190 Mm^3/	Not proved

Fluoride in GW

Acid volcanic rocks (mineral water – granite 6.69 mg/l) – evaporation

Average concentration in CR 0.37 mg/l Rift valley – Shalla 300 mg/l

Concentration for drinking water is related to temperature -

Recommended 0.8 – 1.0 mg/l

Fluoride problem

1.5 mg/l is the tolerance limit for drinking water (WHO,1984).

Concentration above 1.5 mg/l causes dental fluorosis life-long handicap

above 4 mg/l skeletal fluorosis – joint pains, limitation of mobility, invalidity

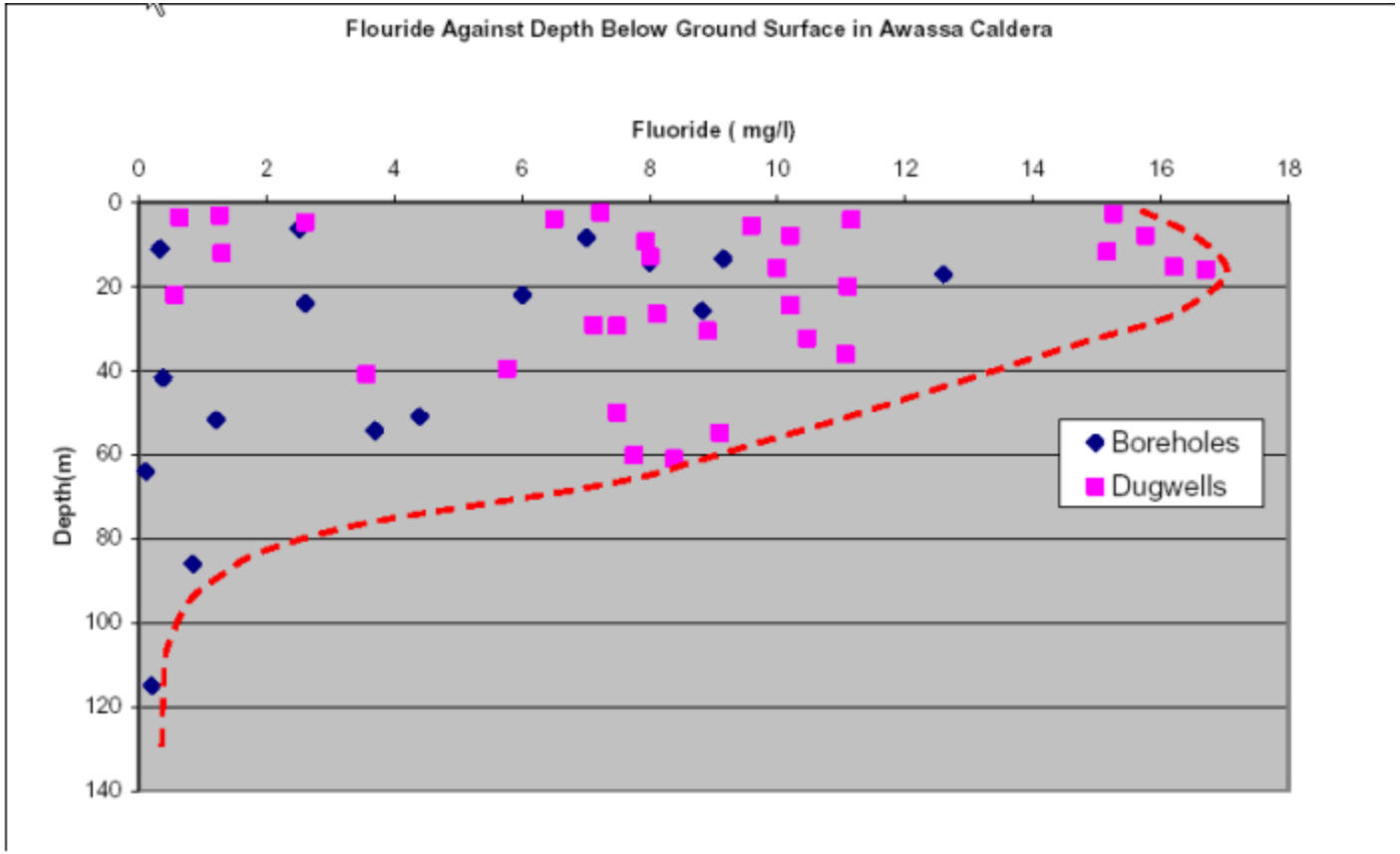
above 10 mg/l; crippling fluorosis – in areas with poor childern nutrition can lead to deformity of lower limbs

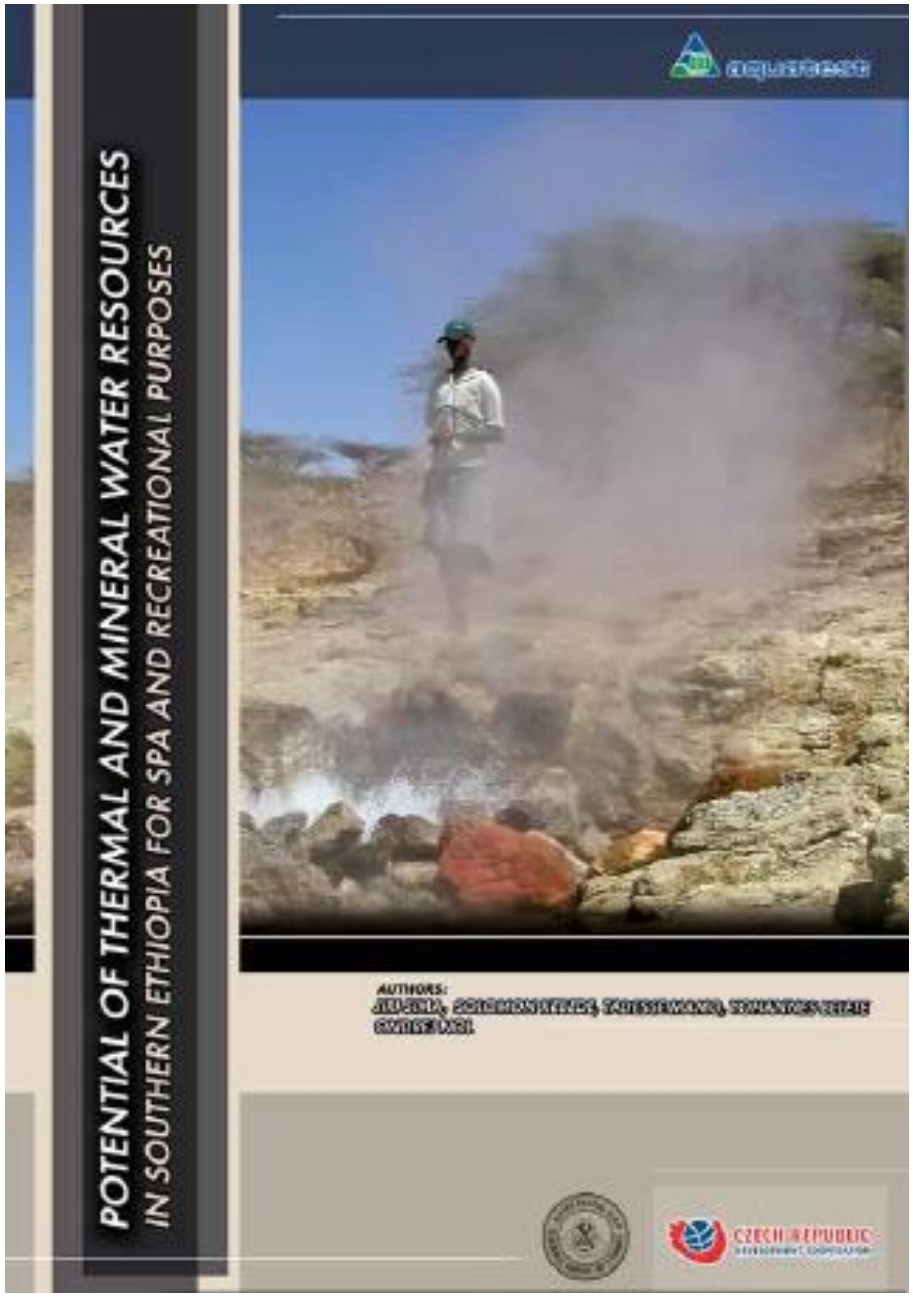
„Elimination“ of fluoride

- Water treatment
- Development of aquifers (part) with lower F

1. Prefer the location of the boreholes on the outcrops of dark rocks (basalt, trachyte, rhyolite and ignimbrite).
2. In light-colour volcanic-sedimentary rocks perform a geophysical survey to determinate the boundary between these rocks and the underlying volcanic rocks.
3. To locate the open section of the well in the fissured part of the volcanic rocks (deeper part of aquifer – Zenaw).
4. To obdurate the overlying volcanic-sedimentary rocks in the boreholes by a cement seal to avoid fast penetration of the water from these rocks along the stem of the well

Zenaw, 2003


Flouride Against Depth Below Ground Surface in Awassa Caldera
Fluoride (mg/l)
0
2
4
6
8
10
12
14
16
18
Depth(m)
0
20
40
60
80
100
120
140
Boreholes
Dugwells



Thermal water resources

Thank you for attention